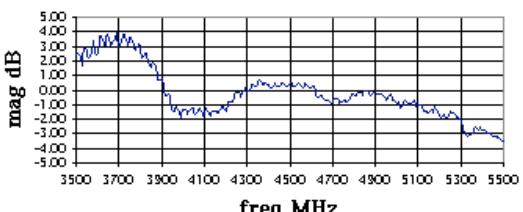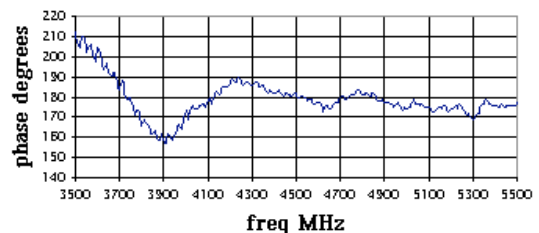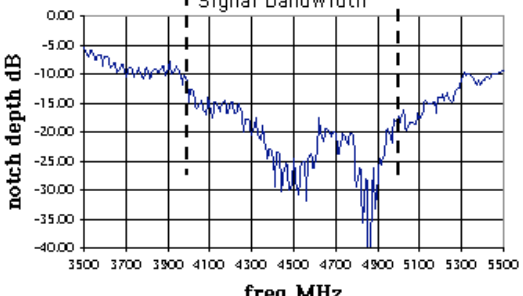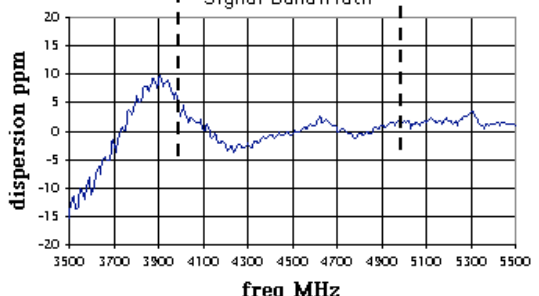Performance of the Debuncher Momentum Cooling Notch Filters
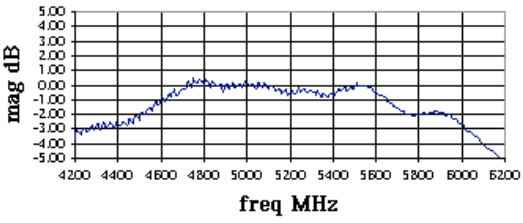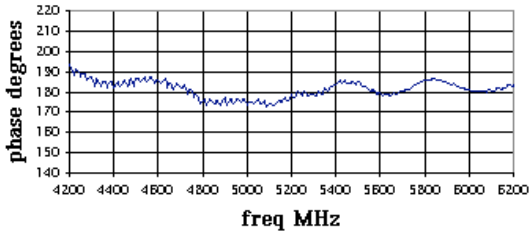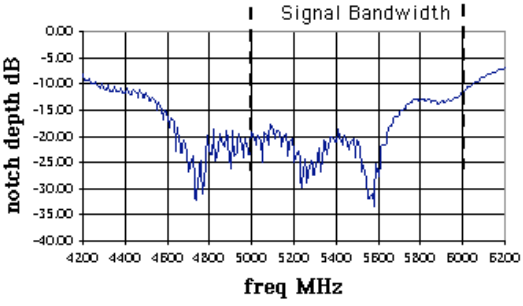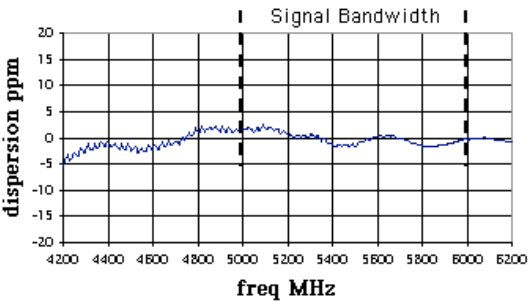Ralph J. Pasquinelli
10/30/02 modified 4/10/03

Pbar stacking rate is controlled by the speed of stochastic cooling in the Debuncher and the momentum spread of freshly injected pbars to the Accumulator. The Main Injector is capable of 1.5-second repetition rates. It is currently ramping at a 2 to 2.2 second rate due to limitations of the cooling systems. To attain the maximum possible stacking rate, cooling needs to be optimized to take advantage of the faster rep rate.
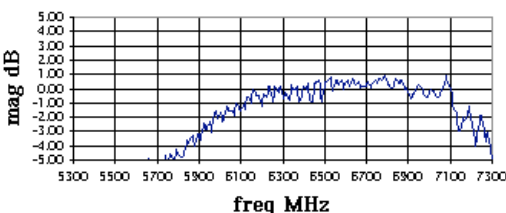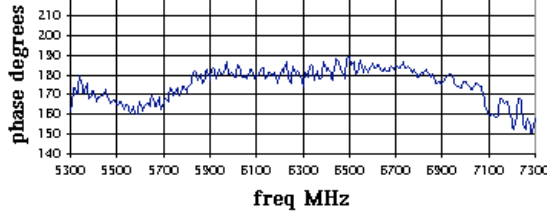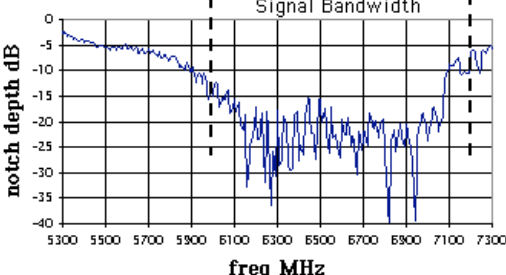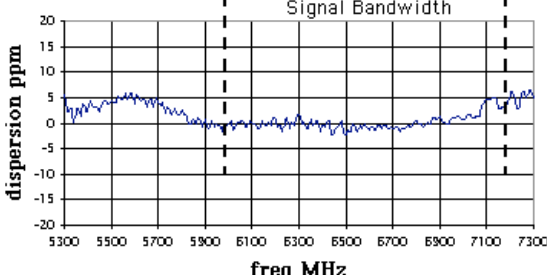
The Debuncher momentum-cooling systems have reached an asymptotic momentum spread that is believed to be higher than expected. An investigation to understand the performance of the notch filters, which control the momentum cooling systems, was undertaken. Each of the four notch filters was measured in situ by using the network analyzer and switch tree that connects the cooling systems. The filters were calibrated on the short leg and data taken for the long leg. The result is a vector measurement that captures the amplitude and phase balance for each filter. The phase is delay adjusted for the revolution frequency. The delay and effective notch filter frequency are displayed. The delay is adjusted to minimize the integral signal notch depth parameter. This is a summation of the notch depth over the signal bandwidth for each filter as displayed by the dotted lines on the graphs. This value of delay is also used to calculate the notch filter dispersion, which, overall, looks very good. The dispersion is a measure of the variation in notch frequency from true harmonic behavior. Finally, the effective notch depth (taking into account the effects of dispersion) at harmonics of the revolution frequency is plotted for each filter.
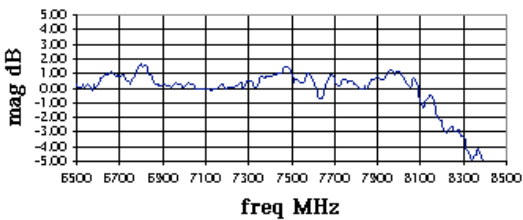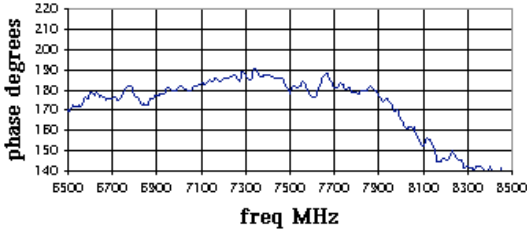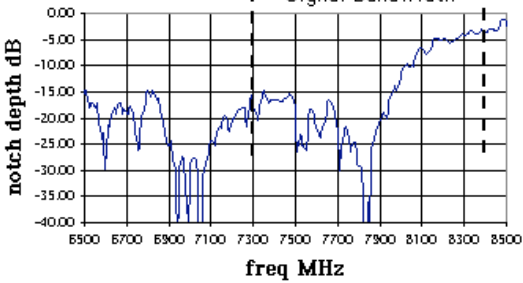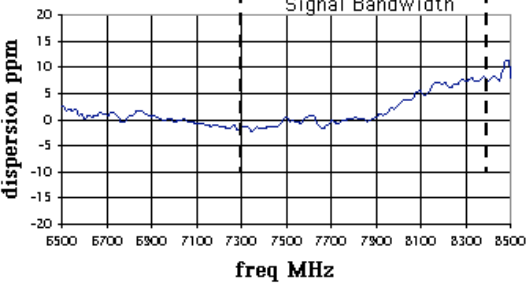
As can be seen from the plots, notch depth from the initial measurements is poor in some of the bands, most notably bands 2 and 4. The original notch filters were designed based on the predicted frequency response of the pickups. Some frequency shift resulted, which will necessitate the redesign of the notch filter equalizers to improve performance in the signal bandwidth. In all cases, the noted signal bandwidth is that from measured performance as documented in RFI note 24 and Pbar note 667.

This data was also analyzed for notch frequency distribution. The actual notch depth and frequency for each band was analyzed and combined. Two plots with Gaussian fits are appended. The following data set contains performance data on original and new equalizer measurements.

10/25/02 Debuncher Band 1 Notch Filter Performance

D:P1TMF filter trombone at 272 ps

magnitude match calibrated on short leg

delayed adjusted phase

Notch Depth dB

Signal Bandwidth

dispersion

Signal Bandwidth

fo	590033.68			
delay sec	1.6948185E-06			
integral signal notch depth		9.83	adjust delay for minimum value in signal bandwidth	

10/25/02 Debuncher Band 2 Notch Filter Performance

D:P2TMF filter trombone at 135 ps

magnitude match calibrated on short leg

delayed adjusted phase

Notch Depth dB

dispersion

fo	**590033.72**
delay sec	**1.6948184E-06**
integral signal notch depth	12.28 adjust delay for minimum value in signal bandwidth

10/25/02 | **Debuncher Band 3 Notch Filter Performance**

D:P3TMF filter trombone at 257 ps

magnitude match calibrated on short leg

mag dB vs freq MHz (5300–7300)

delayed adjusted phase

phase degrees vs freq MHz (5300–7300)

Notch Depth dB

Signal Bandwidth

notch depth dB vs freq MHz (5300–7300)

dispersion

Signal Bandwidth

dispersion ppm vs freq MHz (5300–7300)

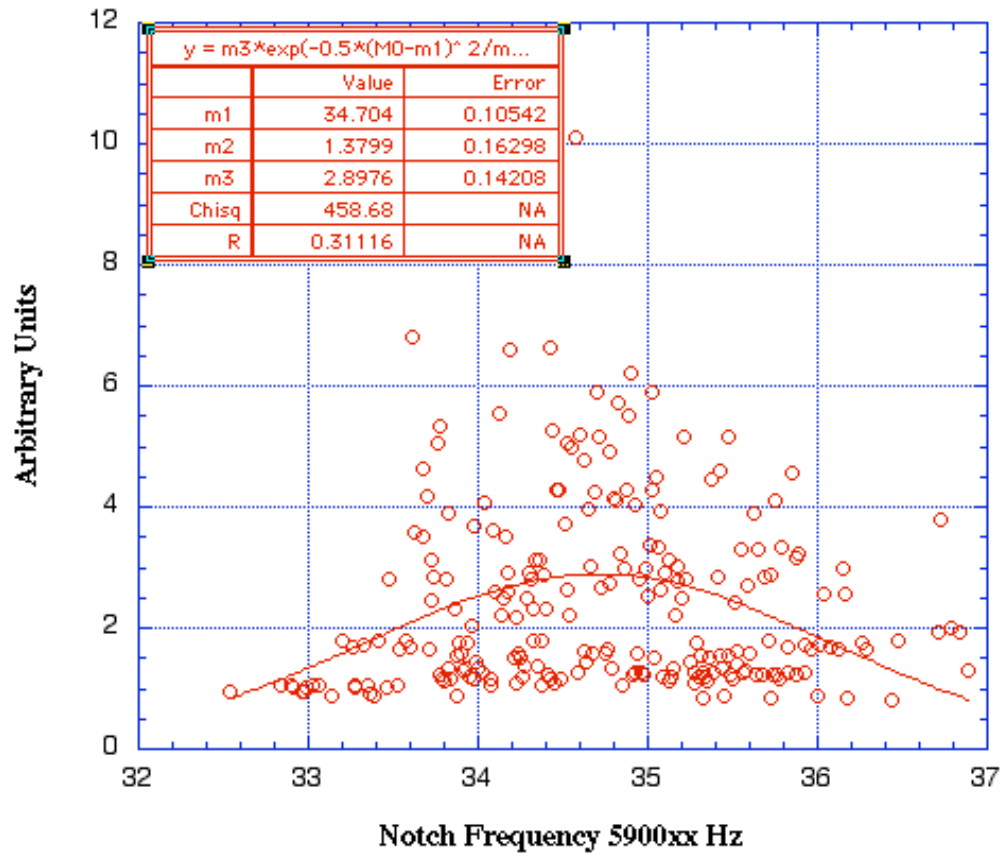|		
fo	590034.41	
delay sec	1.6948164E-06	
integral signal notch depth	14.0683	adjust delay for minimum value in signal bandwidth

Debuncher Band 4 Notch Filter Performance

D:P4TMF filter trombone at 294 ps

magnitude match calibrated on short leg

delayed adjusted phase

Notch Depth dB

Signal Bandwidth

dispersion

Signal Bandwidth

fo	590035.46					
delay sec	1.6948134E-06					
integral signal notch depth	30.77	adjust delay for minimum value in signal bandwidth				

Debuncher Notch Distribution All Bands
Tuned 590035
Original Data 10/25/02

$y = m3*exp(-0.5*(M0-m1)^2/m...$

	Value	Error
m1	34.704	0.10542
m2	1.3799	0.16298
m3	2.8976	0.14208
Chisq	458.68	NA
R	0.31116	NA

Notch Frequency 5900xx Hz

Arbitrary Units

Debuncher Band 1 Notch Filter Performance

D:P1TMF filter trombone at 183 ps

magnitude match calibrated on short leg

delayed adjusted phase
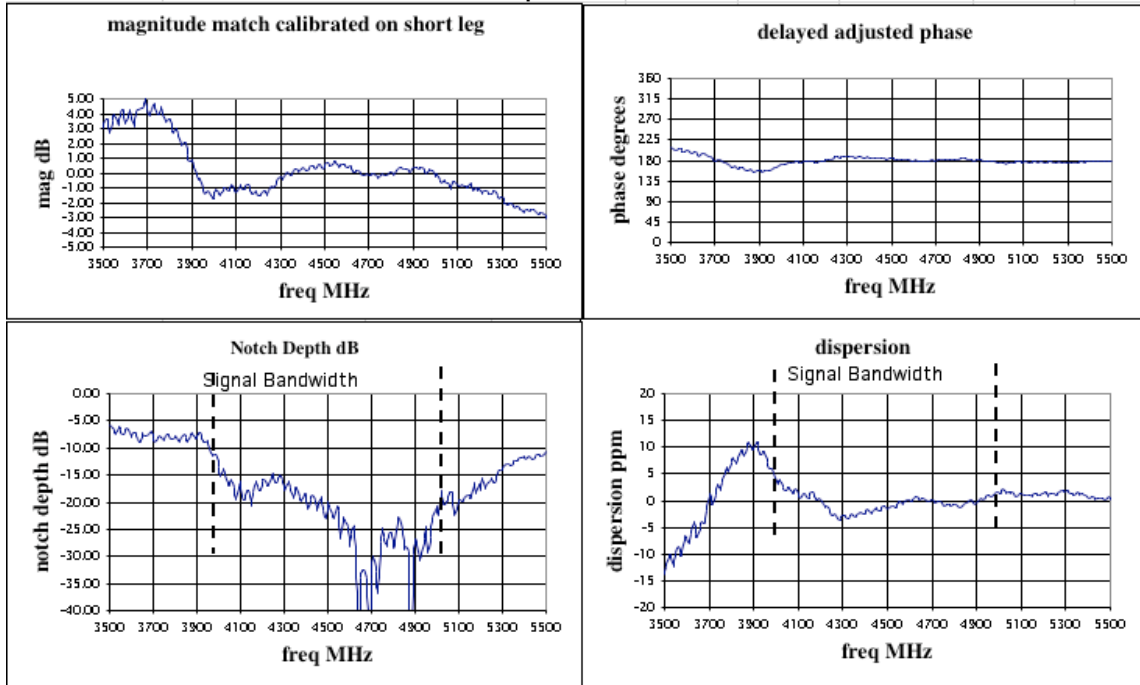
Notch Depth dB

dispersion

Debuncher Band 2 Notch Filter Performance

D:P2TMF filter trombone at 159 ps

magnitude match calibrated on short leg

delayed adjusted phase

Notch Depth dB

dispersion

Debuncher Band 3 Notch Filter Performance

D:P3TMF filter trombone at 100 ps

magnitude match calibrated on short leg

delayed adjusted phase

Notch Depth dB

Signal Bandwidth

dispersion

Signal Bandwidth

Debuncher Band 4 Notch Filter Performance

D:P4TMF filter trombone at 154 ps

magnitude match calibrated on short leg

delayed adjusted phase

Notch Depth dB

Signal Bandwidth

dispersion

Signal Bandwidth
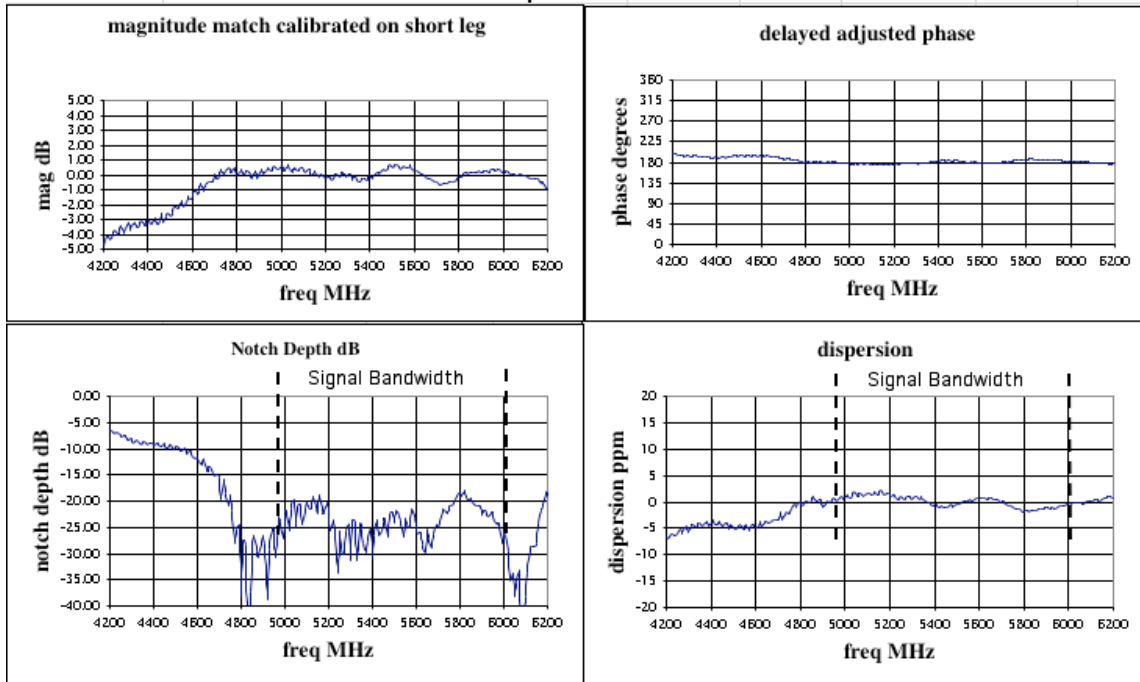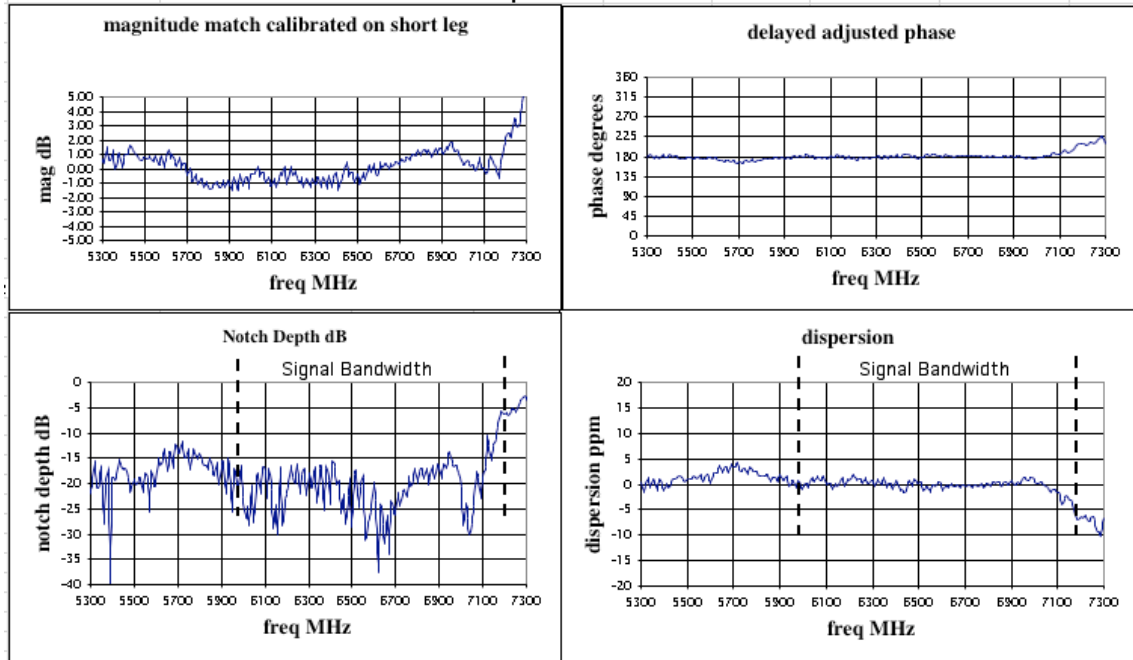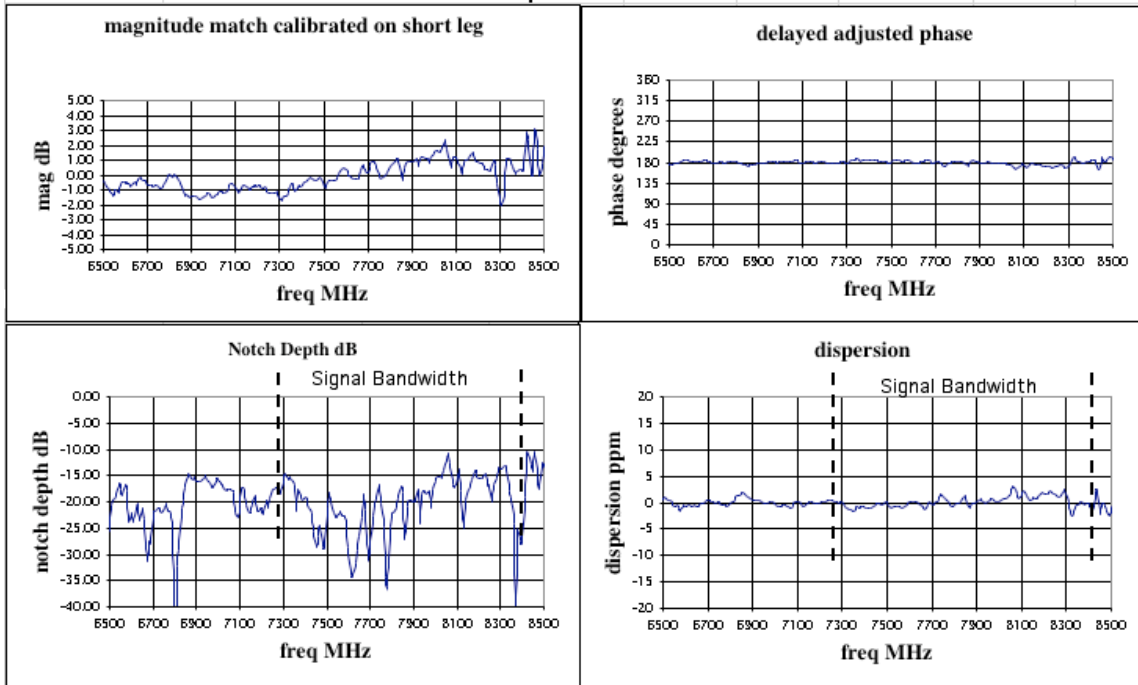
Debuncher Notch Distribution All Bands
Tuned to 590035 Hz

y = m3*exp(-0.5*(M0-m1)^2/m...		
	Value	Error
m1	34.953	0.049031
m2	0.81437	0.059477
m3	4.1737	0.19171
Chisq	600.66	NA
R	0.5328	NA

Notch Frequency 5900xx Hz

Arbitrary Units